

CM What is claimed is:

1. A high resolution, high exposure speed, large effective field size scan and repeat lithography system for producing precise images of a pattern that is present on a mask onto a substrate, comprising:

PI (a) a substrate stage capable of scanning a substrate in one dimension and, when not scanning in that dimension, capable of moving laterally in a direction perpendicular to the scan direction so as to position the substrate for another scan; said substrate stage thus being capable of exposing the full substrate by breaking up the substrate area into a certain number of parallel strips, and exposing each of said strips by scanning the length of the strip across a fixed illumination region;

PI (b) a mask stage capable of scanning in the same dimension as, and synchronized with, the substrate stage, at a speed equal to the substrate stage scanning speed multiplied by a certain ratio M;

PI (c) an illumination subsystem having the desired characteristics of wavelength and intensity distribution, having an effective source plane in the shape of a polygon, and capable of uniformly illuminating a polygon-shaped region on the mask;

PI (d) a projection subsystem for imaging the said polygon-shaped illuminated region on the mask onto the substrate, having an object-to-image reduction ratio M, having the desired image resolution, and having an image field in the shape of a polygon and of an area smaller than the desired effective image field size of the said lithography system; and

PI (e) control means to operatively interrelate said substrate stage, said mask stage and said illumination subsystem, and to provide complementary exposures in an overlap region between the areas exposed by adjacent scans in such a way that the exposure dose distribution received in the overlap region is seamless, and such that the exposure dose delivered across the entire substrate is uniform.

2. A scan and repeat lithography system according to Claim 1, wherein:

PI (a) said illumination subsystem has an effective source plane in the shape of a regular hexagon, and illuminates a regular-hexagon-shaped region on the mask, and said regular-hexagon-shaped region is so oriented that two of its

sides are perpendicular to the scan direction;

PI (b) said projection subsystem has an image field in the shape of a regular hexagon, and said regular hexagon is so oriented that two of its sides are perpendicular to the scan direction; and

PI (c) the effective width,  $w$ , of each substrate scan, as defined by the lateral separation between the center lines of two adjacent scans, is given by PS

TI  $w = 1.5 l_h$ ,  
PI+10 where  $l_h$  is the length of each side of the regular-hexagon-shaped image field on the substrate.

3. A scan and repeat lithography system according to claim 2, wherein said effective width of each substrate scan is equal to the width of each chip on the substrate, where the width of each chip on the substrate is defined as the periodic distance at which the chips on the substrate repeat in the direction perpendicular to the scan direction.

4. A scan and repeat lithography system according to claim 1, wherein:

PI (a) the direction of the substrate travel in any scan is opposite to the direction of the substrate travel in an adjacent scan; and

PI (b) the direction of the mask travel in any scan is opposite to the direction of the mask travel in an adjacent scan.

5. A scan and repeat lithography system according to claim 1, wherein:

PI (a) the number of chip fields on the mask in the direction of scan, equal to a certain number  $N_m$ , is less than the number of chips in the longest scan on the substrate; and

PI (b) said control means monitors scanning and, upon determination of synchronous scanning by the substrate and mask stages of every  $N_m$  chips, provides for the substrate stage to pause momentarily, the mask stage to reset to its original position, and for synchronous scanning of the substrate and mask stages to resume.

6. A scan and repeat lithography system according to claim 1, wherein said illumination subsystem provides radiation that is pulsed with a certain repetition frequency.

7. A scan and repeat lithography system according to claim 6, wherein said

pulsed radiation is emitted by an excimer laser.

8. A scan and repeat lithography system according to Claim 1, wherein said illumination subsystem provides X-ray illumination of a polygon-shaped region on the mask.

9. A scan and repeat lithography system according to Claim 1, wherein said illumination subsystem provides electron beam illumination of a polygon-shaped region on the mask.

10. A scan and repeat lithography system according to Claim 6, wherein:

P1 (a) the scanning of the substrate stage is made up of a multiple of a certain unit movement of length  $d_s$ , such that PS

T1  
P1+10 
$$d_s = v_x / f,$$

where  $v_x$  is the effective substrate scan speed and  $f$  is the pulse repetition frequency of the illumination subsystem; and

P1 (b) the mask stage scanning is made up of a multiple of a unit movement of length  $d_m$ , such that PS

T1 
$$d_m = M d_s.$$

11. A scan and repeat lithography system according to Claim 10, wherein said control means provides for realigning the mask and the wafer with respect to each other periodically, determining the interval between successive realignments by monitoring during said interval the number of pulses emitted by said illumination system.

12. A scan and repeat lithography system according to Claim 11, wherein the number of pulses emitted by said illumination system during said interval between successive realignments is a multiple of  $l_c f / v_x$ , where  $l_c$  is the length of a chip on the substrate in the scan direction.

13. A scan and repeat lithography system according to Claim 1, wherein said mask stage, in addition to being capable of scanning in said manner, is also capable of moving laterally in a direction perpendicular to the scan direction.

14. A scan and repeat lithography system according to Claim 1, wherein;

P1 (a) said object-to-image reduction ratio of said projection subsystem is 5; and, B

P1 (b) said ratio of mask scanning speed to substrate scanning speed is 5. <sup>13</sup>

15. A scan and repeat lithography system according to Claim 1, wherein;

P1 (a) said object-to-image reduction ratio of said projection subsystem is 1; <sup>13</sup>  
and,

P1 B (b) said ratio of mask scanning speed to substrate scanning speed is 1.

B, 3> 16. A scan and repeat lithography system according to Claim 1, wherein the wavelength of said illumination system lies in the region  $251 \pm 3$  nm.

17. The method for providing a scan and repeat lithography system for high-resolution, large-field, high-speed lithography, characterized by the following steps:

P1 (a) Providing a substrate stage for holding the substrate, and capable of scanning the substrate in one dimension, and capable of moving laterally in a direction perpendicular to the scan direction;

P1 (b) Providing a mask stage for holding the mask, and capable of scanning the mask in the same dimension as the substrate stage;

P1 (c) Providing an illumination subsystem having the desired characteristics of wavelength and intensity distribution, having an effective source plane in the shape of a polygon, and capable of uniformly illuminating a polygon-shaped region on the mask;

P1 (d) Providing a projection subsystem for imaging the said polygon-shaped illuminated region on the mask on to the substrate, having an object-to-image reduction ratio  $M$ , having the desired image resolution, and having an image field in the shape of a polygon and of an area smaller than the desired effective image field size of the said lithography system;

P1 (e) Providing a mask which has a certain number of complete, patterned chip fields, and additional patterned areas that fall within the hexagonal illuminated region on the mask;

P1 (f) Scanning the substrate across the polygonal substrate illumination region at a certain velocity  $v_x$ , and simultaneously scanning the mask in a parallel direction across the polygonal mask illumination region at a velocity  $Mv_x$ ;

P1 (g) Stopping the scanning of the substrate and mask stages upon completion of

a scan across the total length of the substrate along the direction of scan, moving the substrate by a certain distance in a direction perpendicular to the scan direction, and resuming the scanning of the substrate and the mask stages in directions opposite to their respective directions in step (f);

P1 (h) Providing complementary exposures in an overlap region between the areas exposed by adjacent scans in such a way that a seam in the exposure dose distribution received on the substrate is absent between the said scans, and such that the exposure dose delivered across the entire substrate is uniform;

P1 (i) Repeating steps (f) - (h) until exposure of the entire substrate is completed. 4

18. The method according to claim 17, further including the step of aligning the substrate and mask stages at the desired interval during steps (f) - (i). 14

19. The method according to claim 17, further including the step of repetitively stopping the scanning of the substrate and mask stages momentarily upon completion of the exposure of a certain number of chips less than the number of chips on the longest substrate scan, resetting the mask stage to its starting position, and resuming the scanning of the substrate and mask stages;

20. A high resolution, high exposure speed, large effective field size scan and repeat lithography system for producing precise images of a pattern that is present on a mask onto a substrate, comprising:

P1 (a) a substrate stage capable of scanning a substrate in a certain dimension x, and simultaneously capable of scanning the substrate in a direction y which is perpendicular to the direction x, so as to enable the substrate stage, while it is completing one scan in the x-dimension, to simultaneously move laterally in the y-direction and thus position the substrate for another scan in the x-dimension; said substrate stage thus being capable of exposing the full substrate by breaking up the substrate area into a certain number of strips, and exposing each of said strips by scanning the length of the strip across a fixed illumination region;

P1 (b) a mask stage capable of scanning in the same two dimensions as, and synchronized with, the substrate stage, at speeds in the x- and y-directions which are faster than the corresponding substrate stage scanning speeds by a certain ratio M;

PI (c) an illumination subsystem having the desired characteristics of wavelength and intensity distribution, having an effective source plane in the shape of a polygon, and capable of uniformly illuminating a polygon-shaped region on the mask;

PI (d) a projection subsystem for imaging the said polygon-shaped illuminated region on the mask on to the substrate, having an object-to-image reduction ratio  $M$ , having the desired image resolution, and having an image field in the shape of a polygon and of an area smaller than the desired effective image field size of the said lithography system; and

PI (e) control means to operatively interrelate said substrate stage, said mask stage and said illumination subsystem, and to provide complementary exposures in an overlap region between the areas exposed by adjacent scans in such a way that the exposure dose distribution received in the overlap region is seamless, and such that the exposure dose delivered across the entire substrate is uniform.

21. The method for providing a scan and repeat lithography system for high-resolution, large-field, high-speed lithography, characterized by the following steps:

PI (a) Providing a substrate stage for holding the substrate, and capable of scanning the substrate simultaneously in certain two dimensions  $x$  and  $y$ ;

PI (b) Providing a mask stage for holding the mask, and capable of simultaneously scanning the mask in the  $x$ - and  $y$ -dimensions;

PI (c) Providing an illumination subsystem having the desired characteristics of wavelength and intensity distribution, having an effective source plane in the shape of a polygon, and capable of uniformly illuminating a polygon-shaped region on the mask;

PI (d) Providing a projection subsystem for imaging the said polygon-shaped illuminated region on the mask on to the substrate, having an object-to-image reduction ratio  $M$ , having the desired image resolution, and having an image field in the shape of a polygon and of an area smaller than the desired effective image field size of the said lithography system;

PI (e) Scanning the substrate simultaneously in the  $x$ - and  $y$ -dimensions across the polygonal substrate illumination region at certain velocities in the two

dimensions, and simultaneously scanning the mask in the x- and y-dimensions across the polygonal mask illumination region at velocities which are equal to the corresponding substrate stage scanning velocities multiplied by M;

P1 (f) Stopping the scanning of the substrate and mask stages upon completion of a scan across the total length of the substrate in the x-dimension, reversing the direction of the scan in the x-dimension, and resuming the simultaneous two-dimensional scanning of the substrate and the mask stages as in step (e);

P1 (g) Providing complementary exposures in an overlap region between the areas exposed by adjacent parallel scans in such a way that a seam in the exposure dose distribution received on the substrate is absent between the said scans, and such that the exposure dose delivered across the entire substrate is uniform; and

P1 (h) Repeating steps (e) - (g) until exposure of the entire substrate is completed.

22. The method according to Claim 21, further including the step of aligning the substrate and mask stages at the desired interval during steps (e) - (h).

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